

Gould, D. J., Moralejo, D., Drey, N. & Chudleigh, J. H. (2011). Interventions to improve hand hygiene compliance in patient care. Cochrane Database of Systematic Reviews(8), doi: 10.1002/14651858.CD005186.pub3 <<http://dx.doi.org/10.1002/14651858.CD005186.pub3>>



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Interventions to improve hand hygiene compliance in patient care (Review)

Gould DJ, Moralejo D, Drey N, Chudleigh JH



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[Intervention Review]

Interventions to improve hand hygiene compliance in patient care

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Editorial group: Cochrane Effective Practice and Organisation of Care Group.

Publication status and date: Edited (no change to conclusions), published in Issue 8, 2011.

Review content assessed as up-to-date: 2 August 2010.

Citation: Gould DJ, Moralejo D, Drey N, Chudleigh JH. Interventions to improve hand hygiene compliance in patient care. *Cochrane Database of Systematic Reviews* 2010, Issue 9. Art. No.: CD005186. DOI: 10.1002/14651858.CD005186.pub3.

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ABSTRACT

Background

Health care-associated infection is a major cause of morbidity and mortality. Hand hygiene is regarded as an effective preventive measure.

Objectives

To update the review done in 2007, to assess the short and longer-term success of strategies to improve hand hygiene compliance and to determine whether a sustained increase in hand hygiene compliance can reduce rates of health care-associated infection.

Search strategy

We conducted electronic searches of: the Cochrane Central Register of Controlled Trials; the Cochrane Effective Practice and Organisation of Care Group specialised register of trials; MEDLINE; PubMed; EMBASE; CINAHL; and the BNI. Originally searched to July 2006, for the update databases were searched from August 2006 until November 2009.

Selection criteria

Randomised controlled trials, controlled clinical trials, controlled before and after studies, and interrupted time series analyses meeting explicit entry and quality criteria used by the Cochrane Effective Practice and Organisation of Care Group were eligible for inclusion. Studies reporting indicators of hand hygiene compliance and proxy indicators such as product use were considered. Self-reported data were not considered a valid measure of compliance. Studies to promote hand hygiene compliance as part of a care bundle approach were included, providing data relating specifically to hand hygiene were presented separately. Studies were excluded if hand hygiene was assessed in simulations, non-clinical settings or the operating theatre setting.

Data collection and analysis

Two reviewers independently extracted data and assessed data quality.

Main results

Four studies met the criteria for the review: two from the original review and two from the update. Two studies evaluated simple education initiatives, one using a randomized clinical trial design and the other a controlled before and after design. Both measured hand hygiene compliance by direct observation. The other two studies were both interrupted times series studies. One study presented

three separate interventions within the same paper: simple substitutions of product and two multifaceted campaigns, one of which included involving practitioners in making decisions about choice of hand hygiene products and the components of the hand hygiene program. The other study also presented two separate multifaceted campaigns, one of which involved application of social marketing theory. In these two studies follow-up data collection continued beyond 12 months, and a proxy measure of hand hygiene compliance (product use) was recorded. Microbiological data were recorded in one study. Hand hygiene compliance increased for one of the studies where it was measured by direct observation, but the results from the other study were not conclusive. Product use increased in the two studies in which it was reported, with inconsistent results reported for one initiative. MRSA incidence decreased in the one study reporting microbiological data.

Authors' conclusions

The quality of intervention studies intended to increase hand hygiene compliance remains disappointing. Although multifaceted campaigns with social marketing or staff involvement appear to have an effect, there is insufficient evidence to draw a firm conclusion. There remains an urgent need to undertake methodologically robust research to explore the effectiveness of soundly designed and implemented interventions to increase hand hygiene compliance.

PLAIN LANGUAGE SUMMARY

Methods to improve healthcare worker hand hygiene to decrease infection in hospitals

Patients in hospital, nursing homes and long-term care facilities are at high risk of developing infections that they did not have before admission. Most healthcare-associated infections are spread by direct contact, especially via the hands of healthcare workers. Traditionally, hand hygiene, such as washing hands before and after touching patients, has been considered the single most important way of reducing infections. Increasingly, the use of alcohol-based hand rub is used alongside or in replacement of traditional washing with soap and water. However, compliance with hand hygiene is poor.

This updated review sought to establish whether there are effective strategies to improve hand hygiene compliance, whether such strategies are effective over short or longer term and whether increased compliance reduces healthcare-associated infections.

There were four studies, two from the original review in 2007 and two from the update, which assessed the success of campaigns to improve hand hygiene compliance. Follow-up continued for longer than 12 months in two of the studies, but none of the studies was of high quality. Success in improving hand hygiene was inconsistent among the four studies.

There is still not enough evidence to be certain what strategies improve hand hygiene compliance. Introducing alcohol-based hand rub accompanied by education/training is not enough, while using multiple strategies, including involvement of staff in planning activities or applying social marketing strategies, may be helpful. More research is needed.

BACKGROUND

Description of the condition

In England, 8.2% of patients admitted to hospital develop healthcare-associated infections (HAIs) ([Hospital Infection Society 2007](#)). HAIs cause 5,000 deaths and cost £930 million annually ([National Audit Office 1998](#)). In the United States (US), an estimated 5% of patients develop HAIs, at a cost of 4.5 billion USD per year. This translates to an estimated two million cases of HAIs per annum, accounting for nearly 100,000 deaths ([Klebens](#)

[2007](#)). In Canada, an estimated 220,000 HAIs occur each year, with 8,000 related deaths ([Zoutman 2003](#)). Infection control experts everywhere are working to identify and correct factors that contribute to these rates. Although hand hygiene has long been regarded as the most effective preventive measure ([Teare 1999](#)), numerous studies over the past few decades have demonstrated that compliance with hand hygiene recommendations is poor and interventions are not effective long term.

[Naikoba 2001](#) systematically reviewed 21 studies published before the year 2000. They classified 17 studies as uncontrolled trials, and of these, 15 took place in intensive care units (ICUs). Numer-

ous different interventions and combinations of interventions to improve hand hygiene were examined. The reviewers concluded that multifaceted approaches promoted hand hygiene compliance more effectively than approaches involving a single type of intervention. Additionally, education with written information, reminders and continuous feedback on performance were more useful than the other interventions assessed, such as automated sinks or provision of moisturised soaps. However, more recently published work has indicated that multifaceted interventions are not likely to be more successful than single interventions in changing practice (Grimshaw 2004) and that audit with feedback has only a modest effect on improving practice (Jamtvedt 2006).

Naikoba 2001 noted multiple limitations of the studies, including small sample sizes, short duration of follow-up, lack of or inappropriate control groups, lack of generalisability from the ICU to other settings, and emphasis on frequency of hand hygiene as an outcome measure rather than microbiological data. One key limitation of the review was that it included studies that had weak designs for making causal inferences about the effects of interventions (mainly uncontrolled before and after studies). Another disadvantage is the failure of the authors to consider variables that might influence rates of HAIs. Seasonal variations are particularly likely to influence outcome measures in studies that examine hand hygiene. For example, bacterial counts are affected by seasonal factors such as humidity. Hand hygiene compliance is likely to be influenced by factors such as staffing levels and replacement of the usual staff by agency nurses or float staff at times such as national holidays or in the event of staff sickness.

Description of the intervention

In the years since the systematic review by Naikoba 2001, the topic of hand hygiene has received increasing attention in the UK, Europe, North America and Australia. The public is alarmed by the high incidence of HAIs and health providers must now demonstrate the effectiveness of infection control policies. Pittet 2000 published the results of a Swiss initiative that used an uncontrolled before and after design to demonstrate that a hospital-wide poster campaign, combined with performance feedback and alcohol-based hand rub placed at every bedside, led to sustained improvement in hand hygiene for nursing but not medical staff, as well as reduction in HAIs and methicillin-resistant *Staphylococcus aureus* (MRSA) transmission. Follow-up data published independently revealed continuing success (Hugonnet 2002). Since then, a number of countries have implemented widespread hand hygiene campaigns, with little evidence to base decisions about which interventions are the most effective.

Why it is important to do this review

In 2007, we published a systematic review of interventions to improve hand hygiene compliance in patient care. We considered controlled trials and interrupted time series analyses published between 1980 and July 2006. Of the 49 studies that were potentially eligible, only two met the criteria for inclusion. Both examined education as a single intervention. Huang 2002 found a significant increase in hand hygiene compliance four months post-intervention, whereas Gould 1997 found no difference three months post-intervention. Studies conducted between 2001 and 2006 (after Naikoba 2001), shared the same limitations in study design as those conducted earlier. Sample sizes remained small and most lacked either a suitable comparison group or any control group at all. Thus, in 2007, because of a lack of high quality evidence, we were unable to draw a conclusion about effectiveness of interventions to promote hand hygiene.

Given the continued interest in improving hand hygiene as a preventive strategy, and the publication of a large number of new studies since July 2006, a reappraisal of available evidence is warranted. The purpose of our updated review was to identify all studies investigating the effectiveness of interventions intended to increase hand hygiene compliance short and longer-term, and to determine the success of these interventions in terms of hand hygiene compliance and subsequent effect on rates of HAIs.

OBJECTIVES

1. To assess the short and long term success of strategies to improve hand hygiene compliance in patient care.
2. To determine whether a sustained increase in hand hygiene compliance can reduce rates of health care-associated infection.

METHODS

Criteria for considering studies for this review

Types of studies

We considered randomised controlled trials (RCTs), controlled clinical trials (CCTs), controlled before and after studies (CBAs) and interrupted time series analyses (ITSs) meeting explicit entry and quality criteria used by the Cochrane Effective Practice and Organisation of Care Group (EPOC). Studies reporting proxy indicators of hand hygiene compliance, for example increased use of soap or alcohol-based hand rub, were considered. To be eligible for review, ITS studies had to demonstrate a clearly defined point in time when the intervention occurred, and had to include at least three data collection points before and after the intervention to

take into account the influence of secular trends and the auto-correlation among measurements repeatedly taken over time (Ramsay 2003). All studies also had to have objective measurements of the outcome of interest, as well as relevant and interpretable data presented or obtainable.

Types of participants

We considered studies where the participants or target groups were nurses, doctors and other allied health professionals (except operating theatre staff) in any hospital or community setting, in any country. Studies concentrating on operating theatre staff were excluded because specific hand hygiene techniques are used in this setting.

Types of interventions

We considered any intervention intended to improve compliance with hand hygiene using aqueous solutions and/or alcohol based products. For example, we considered education, audit with performance feedback, health promotion, and variations in availability and type of products used for hand hygiene. Studies of interventions to promote hand hygiene compliance were potentially eligible regardless of whether the intervention occurred in outbreak or non-outbreak situations. Studies to promote compliance with universal or infection control precautions were considered for inclusion, providing data relating specifically to hand hygiene were presented separately. Similarly, studies to promote hand hygiene compliance as part of a care bundle approach were eligible, providing data relating specifically to hand hygiene or a proxy measurement for hand hygiene were presented separately. Studies were excluded if hand hygiene was assessed in simulations or artificial settings outside the clinical environment.

Types of outcome measures

Our primary outcome of interest was:

- Rates of observed hand hygiene compliance and/or a proxy indicator of hand washing compliance (e.g. increased use of hand washing products).

Healthcare workers' perceptions of their hand hygiene practices was not considered a valid measure of compliance because there is evidence that self reports are not accurate (Haas 2007).

The following secondary outcomes of interest were also considered in our review, provided that hand hygiene was also reported:

- Reduction in healthcare-associated infection.
- Reduction in colonisation rates by clinically significant nosocomial pathogens.

Search methods for identification of studies

See: Effective Practice and Organisation of Care Group methods used in reviews (Ballini 2010).

Electronic searches

The following electronic databases were searched, from the identified starting date as relevant up to July 2006 for the initial review, and from August 2006 up to November 2009 for the update:

- a) The EPOC Register (and the database of studies awaiting assessment) (see SPECIALISED REGISTER under GROUP DETAILS);
- b) The Cochrane Central Register of Controlled Trials (CENTRAL);
- c) Bibliographic databases: MEDLINE (from 1980), EMBASE (from 1990), CINAHL (from 1982), and the British Nursing Index (from 1985).

Electronic databases were searched using a strategy incorporating the methodological component of the EPOC search strategy combined with selected MeSH terms and free text terms relating to hand hygiene. The MEDLINE search strategy described below was translated into the other databases using the appropriate controlled vocabulary as applicable (see Appendix A). We did not use language restrictions.

The search strategy used in the original review, which did not specify designs, can be found in Appendix A. An additional search which used broad terms related to infection, also described in Appendix A, did not reveal any additional studies related to interventions to promote hand hygiene.

Search strategy:

- 1 Handwashing/
- 2 (hand antisepsis or handwash\$ or hand wash\$ or hand disinfection or hand hygiene or surgical scrub\$).tw.
- 3 1 or 2
- 4 exp Hand/
- 5 exp Sterilization/
- 6 4 and 5
- 7 3 or 6
- 8 randomized controlled trial.pt.
- 9 controlled clinical trial.pt.
- 10 intervention studies/
- 11 experiment\$.tw.
- 12 (time adj series).tw.
- 13 (pre test or pretest or (posttest or post test)).tw.
- 14 random allocation/
- 15 impact.tw.
- 16 intervention?.tw.
- 17 chang\$.tw.
- 18 evaluation studies/
- 19 evaluat\$.tw.
- 20 effect?.tw.
- 21 comparative study/

22 animal/
 23 human/
 24 22 not 23
 25 or/8-21
 26 25 not 24
 27 7 and 26
 28 27
 29 limit 28 to yr="2005 -Current"
 30 from 29 keep 1

Searching other resources

Additional search strategies, in both review periods, were as follows:

- a) Hand searching: For the original review, we hand-searched the following high-yield journals for the period 1985-July 2006: British Medical Journal; Journal of Hospital Infection; American Journal of Infection Control, Infection Control and Hospital Epidemiology. We similarly hand searched the conference proceedings from the UK Hospital Infection Society and the Infection Prevention Society (previously the Infection Control Nurses' Association). For the updated review, we hand-searched, for the period August 2006 to November 2009, the same journals and conference proceedings as well as the Canadian Journal of Infection Control. Abstracts for the conferences of the American Association for Professionals in Infection Control and Epidemiology (APIC), the Society for Healthcare Epidemiology in America (SHEA) and the Community and Hospital Infection Control Association (CHICA-Canada) were included in the journals searched.
- b) Reference lists of all papers and relevant reviews identified were reviewed to identify any additional references.
- c) Where relevant, authors of papers were contacted regarding any further published or unpublished work.
- d) Colleagues from the professional organizations: WHO, the National Patient Safety Agency, and pharmaceutical companies manufacturing hand hygiene products were contacted to ask if they were aware of any unpublished work within the field.
- e) Authors of other reviews in the field of effective professional practice were contacted regarding relevant studies of which they might be aware.
- f) ISI Web of Science was searched for relevant papers.
- g) The Database of Abstracts of Reviews of Effectiveness (DARE) was searched for related reviews.

Data collection and analysis

The review was conducted using standard EPOC methods (Ballini 2010).

Selection of studies

In the initial review, DJG and JC screened the results of searches to identify potentially relevant papers. Two reviewers (DJG and JC or ND) independently selected the studies to be included in the review. For the update, DJG, ND and DM screened the results of searches to identify potentially relevant papers. Two reviewers (DJG and ND or DM) independently selected the studies to be included in the review.

Data extraction and management

Data from each paper were abstracted independently by two reviewers (DJG and JC, ND or DM in the initial review, and DJG and ND or DM in the update) using the standard EPOC checklist (Ballini 2010). Data abstraction was checked and discrepancies were resolved through discussion by the relevant two reviewers. ND or DM acted as arbitrator for any unresolved difficulties. DJG was included in the authorship of one paper, which was reviewed by JC and ND in the initial review.

Assessment of risk of bias in included studies

We used The Cochrane Collaboration's tool for assessing risk of bias on nine standard criteria: adequate allocation sequence generation, concealment of allocation, similar baseline outcome measures, similar baseline characteristics, adequately addressed incomplete outcome data, adequate prevention of knowledge of allocated interventions, adequate protection against contamination, free from selective reporting, and free of other risk of bias. We used three additional criteria specified by EPOC for ITS studies (Ballini 2010): intervention independent of other changes, shape of the intervention pre-specified, and intervention unlikely to affect data collection.

Data synthesis

Given the substantial heterogeneity of interventions and methods across studies, it was not sensible to use meta-analysis to pool results. Instead, we present the results of studies in tabular form and make a qualitative assessment of the effects of studies, based on quality. We report the following data (where available): pre-intervention study and control data and statistical significance across groups, absolute and percentage improvement.

RESULTS

Description of studies

See: [Characteristics of included studies](#); [Characteristics of excluded studies](#).

Results of the search

In the initial review, once opinion pieces, general reviews and non-intervention studies were excluded, 49 studies, reported in 49 papers and one thesis, appeared potentially eligible for review and were read in detail. The studies evaluated a wide variety of interventions, with cursory descriptions of the intervention(s) in a number of reports. Eleven of the studies involved a single intervention that featured education or training related to hand hygiene, usually combining formal teaching with practical demonstrations (Conly 1989; Berg 1995; Diekema 1995; Dorsey 1996; Gould 1997; Baker 1998; Moongtui 1999; Huang 2002; Shaw 2003; Panhotra 2004; Prieto 2005). Hand hygiene was often covered with other topics such as universal precautions or epidemiology. Dubbert 1990 combined education with audit and feedback, while six studies looked at audit and feedback alone (Raju 1991; Van de Mortel 1995; Tibbals 1996; Van de Mortel 2000; Bittner 2002; Salemi 2002). Seven studies involved single interventions related to introduction of a new hand hygiene product such as emollient soap (Mayer 1986) or alcohol-based hand rub (Graham 1990; Maury 2000; Muto 2000; Earl 2001; Colombo 2002; Brown 2003). Marena 2002 compared plain soap and an antimicrobial solution, in combination with education. Other single interventions studied were use of visual feedback of organisms from hand cultures (Moore 1980), gowns (Donowitz 1986), labeled teddy bear (Hughes 1986), labels on ventilators (Khatib 1999), reminders from patients (McGuckin 1999; McGuckin 2004), posters (Thomas 2005), voice prompts (Swoboda 2004), automated sink (Larson 1991), and move to a new hospital (Whitby 2004). The remaining studies involved multidimensional campaigns featuring different combinations of an educational program, a new product, audit and performance feedback, written information and written reminders such as posters or labels. Theoretical frameworks were only clearly articulated for two studies reported (Larson 2000; Creedon 2005).

In the update, the search yielded 808 possible articles. Once opinion pieces, general reviews and non-intervention studies were excluded, 84 papers published after July 2006 appeared potentially eligible for review and were read in detail. The interventions described in most of the studies have been heavily influenced by the work of Pittet 2000 in Geneva and feature the introduction of alcohol-based hand rub coupled with education/training, performance feedback (usually in written form) and posters. An increasing number of studies report care bundle approaches to improving infection prevention that extend over long periods (up to six years) of which hand hygiene forms only one facet. Descriptions of the interventions in the care bundle studies were generally poor, but were a little better described in the other studies found in the update that focused on hand hygiene as the sole intervention compared to the descriptions found in the studies considered in the original review. There was increased use of infection rates (usually routinely reported surveillance data) in the recent studies compared to the first review and an increase in the number of studies

using product use as a proxy measure for hand hygiene as well, or instead of, direct observation.

Included studies

Two studies were included in the initial review and two studies were added in this update. A brief summary of the studies can be found in the [Characteristics of included studies](#).

In their RCT Huang 2002 recruited 100 nurses who were then randomised into experimental and control groups. The method used for random allocation to group was not specified. They did not specify the number of nurses able to attend the educational intervention, but collected data from 49 of 50 assigned to each group. Data collection from 98 nurses was conducted by direct observation undertaken by three observers for 30 minutes each before the intervention and for four months afterwards. The observers were the investigators; it was not specified as to whether they were blinded to group allocation nor were details of inter-rater reliability testing for the three data collectors supplied. The source of the behaviour observation checklist to assess adherence to universal precautions was not identified, though the investigators were reported to be well trained in universal precautions.

The unit of analysis was the individual nurse. The outcome measure, percent of nurses who performed hand hygiene during the 30 minutes of observation, was not clearly described in terms of whether hand hygiene was performed each time it was required or if it was just performed at any time during the observation period. This outcome is different from that assessed in the majority of hand hygiene studies, for example, proportion of opportunities for hand hygiene where hand hygiene is performed. It is possible that actual adherence was overestimated, although this would apply equally to both groups and not affect the difference between the groups. The possibility of a Hawthorne Effect was not discussed; if it existed it would lead to an overestimation of effect but not affect the difference between groups. Microbiologically-defined outcome measures were not used.

Gould 1997 reported a CBA conducted in four matched surgical wards from the same hospital. Two wards were randomly selected to serve as experimental units, and then two matched wards were selected as controls. Nurses were recruited from the wards, 25 per group, with similar high dropout rates in each group; complete data were obtained from 16 nurses from the experimental group and 15 nurses from the control group. The characteristics of participants in each group were not described, but the wards were similar in structure. Gould 1997 were obliged to cancel half of their teaching sessions because the wards were too busy, resulting in the failure of some nurses to receive all of the intended input. This may have led to dilution of effect. The sample size was small, and the study had limited power for detecting a significant difference.

Each nurse was observed continuously for two hours by the same observer, who was blinded to group allocation. The observation

checklist had been previously validated. The outcome measure was number of hand washes performed after activities judged likely to offer a risk of cross-infection ('essential' hand hygiene episodes). Microbiologically-defined outcome measures were not used. The unit of analysis was the individual nurse. Baseline hand hygiene data were similar in control and experimental wards. The possibility of a Hawthorne Effect (increased productivity i.e. more hand hygiene episodes resulting from the presence of observers) was considered by the authors as unlikely.

The aim of the ITS reported by [Vernaz 2008](#) was to determine the relationship between antibiotic use and use of alcohol-based hand rub on the incidence of MRSA and *Clostridium difficile* (*C. difficile*). In 2003 Social Marketing Theory ([Kotler 1971](#)) was applied to improve adherence to previously implemented guidelines related to standard and isolation precautions. The importance of hand hygiene was mentioned in these guidelines, but the use of alcohol-based hand rub did not receive particular emphasis, although it had been used in the hospital since 1994. The campaign was marketed under the title of *VigiGerme*®. In 2005 a second initiative was introduced as part of the Swiss National Hand Hygiene Promotion Campaign and the [Global Patient Safety Challenge](#) organized by the World Health Organization. The second initiative actively promoted the use of alcohol-based hand rub. New guidelines for the control of MRSA and *C. difficile* were introduced during the ITS. The authors did not provide details of the components of either campaign.

[Vernaz 2008](#) collected monthly data including antibiotic use (defined daily dose), the number of new clinical isolates of MRSA and *C. difficile* per 100 patient-days, and use of litres of alcohol-based hand rub per 100 patient-days. With respect to impact of the interventions on hand hygiene adherence, the latter is the measure of interest. It is a commonly used objective measure of adherence, although it does not distinguish appropriate hand hygiene related to specific patient care indications and other hand hygiene or loss through spillage or theft. The authors used ARIMA modeling, which is appropriate for analyzing ITS data. A potential source of bias was the implementation of MRSA/*C. difficile* control policies and Contact Precautions at the same time. It is not possible to ascertain the effect of hand hygiene, compared to the role of implementation of guidelines for the control of MRSA and *C. difficile*, on the results obtained. However, it seems more likely that the hand hygiene campaigns, rather than the implementation of control guidelines, would be responsible for the increases in use of alcohol-based hand rub that were seen.

The reported aim of the initiative reported by [Whitby 2008](#) was to replicate two different, complex interventions claimed successful elsewhere, in addition to implementing two simple substitutions of alcohol-based hand rub and brief essential training to use it. The participating areas were in geographically different parts of the same hospital to avoid contamination. Baseline data for the simple substitutions were collected July 2004 to October/November 2004. Baseline data for the first complex intervention ('Geneva'

program) took place July 2004 to October 2004. Baseline data for the second complex intervention ('Washington' program) took place July 2004 to November 2004. Two of the interventions took place in parallel over the same two year period (simple and 'Geneva' interventions). The 'Washington' intervention took one month longer because of the additional time required for negotiation with staff. The 'Washington' intervention originally reported by [Larson 2000](#) emphasized the importance of working with staff in different parts of the organization to produce a customized intervention to meet their needs. How the intervention was customized to meet local needs was not clearly described. The difference in time periods is not a source of concern in terms of comparability.

Data in all areas were collected with an electronic monitoring system which measured product use continuously. Microbiological data were not collected. The baseline data for each area were used in the analysis, with four or five months as baseline. The authors describe the designs as before-and-after, yet graphically illustrated the linear trends in hand hygiene frequency. They also used GEE modeling to calculate an incidence rate ratio of the incidence rates of the expected hand hygiene events for the post-intervention period relative to the pre-intervention period. They analyzed the data from five wards separately; we therefore considered these as five separate ITS analyses. The statistical analysis was appropriate. The key risk of bias was in the variability of the various groups; the authors did not attempt to compare interventions because of this variability. Because some of the interventions were carried out in different groups, the lack of control for group characteristics makes it difficult to interpret the results obtained.

Excluded studies

A total of 129 studies (129 papers and one thesis, which was reported in one of the papers) were excluded in both the initial and updated reviews. These studies, and reasons for their exclusion, are presented in the [Characteristics of excluded studies](#).

In the original review, 21 of 47 excluded studies (44.7%) were excluded because they reported uncontrolled before and after study designs, compared to 46 of 82 (56.1%) in the update. One of these studies presented the amalgamated data from 18 developing countries which were reported to have introduced an infection prevention programme which included the same hand hygiene campaign over 10 years ([Rosenthal 2008](#)). It was not clear if baseline data had been collected in any of these countries and the impact of the other numerous changes introduced on hand hygiene compliance and infection was not considered. This initiative was taken to be an uncontrolled before and after study, but it was difficult to reach firm conclusions about the design. Attempts to contact the author failed.

Three ITS studies were excluded from the original review, and 12 from the update, as each had fewer than three pre and post-intervention data collection points. In the original review, an additional 12 studies reported complicated before and after designs in which

two or more sequential interventions had taken place, but with only one or two episodes of data collection after each new intervention, so they could not be analyzed as ITS studies. This group included one study which is very widely quoted as evidence of the ability of hand hygiene campaigns to increase compliance and decrease rates of HAIs (Pittet 2000) and a longer follow-up study building on the original work (Hugonnet 2002). In this group of studies, a single episode of baseline data collection took place with further data collection over extended periods. These long periods of data collection became interventional, because performance feedback was provided to healthcare workers during each as part of a deliberately engineered Hawthorne (productivity) Effect (Roethlisberger 1939).

In the initial review, six CBA studies were excluded, each employing one intervention and one control unit (Mayer 1986; Larson 1991; Larson 1997; Larson 2000; Bittner 2002; Colombo 2002). Key weaknesses of these studies were the dissimilarities of the control and experimental sites and in some studies imbalances in baseline hand hygiene. In addition, because of the limited control group, the intervention was completely confounded by the study site making it difficult to attribute any observed changes to the intervention rather than to other site-specific variables.

In the updated review, two papers reported controlled before and after (CBA) studies which could not be included because the control and intervention groups were too dissimilar to allow valid comparisons (Duerink 2006; Trick 2007). Three controlled clinical trials (CCTs) also failed to meet the inclusion criteria related to appropriate choice of controls (Marra 2008; Kohli 2009; Giannitsioti 2009); either control groups were not comparable or were inadequately described.

Two crossover trials failed to meet the inclusion criteria for trials with respect to having at least two control and two intervention groups (Golan 2006; Rupp 2008). Even though each trial had a unit that acted, in turn, as a control group and intervention group, in the second part of each trial the unit acting as control had already had the intervention. There may have been carryover of the intervention effect at the period 1 intervention site into period 2. Thus, only the first period of each trial could be considered, so each was excluded from further review on the basis of having only one control and one intervention group.

In the initial review, one study, reported in two separate references, was excluded because information pertaining to hand hygiene were not presented separately from data related to universal precautions (Moongtui 1999). Another paper contained no data (Moore 1980), and three were excluded because baseline data were not reported or were collected on only a few of the participating wards (Maury 2000; Panhotra 2004; Thomas 2005).

In the updated review, four papers were excluded because hand hygiene was assessed during simulated activities or in artificial settings not involving real patients (Macdonald 2006; Milward 2007; Elola-Vicente 2008; Hon 2008). Two studies were excluded because careful reading suggested that they had no clear intervention

(Snow 2006; Larson 2007). In the study reported by Snow 2006, student nurses' hand hygiene compliance was measured before and after working with clinical mentors, but the mentors were unaware that they were acting as role models and the authors do not explain how, or even if, their hand hygiene compliance was assessed to ensure that their practice was an acceptable example for students. It is therefore questionable that the role modelling should be considered a true intervention, as no manipulation by the researchers took place. Larson 2007 dichotomized hospitals into those with high and low levels of hand hygiene compliance according to nationally collected statistics. Category of compliance was then correlated with whether or not the hospital had a high or low level of compliance with nationally implemented and updated infection prevention guidelines. No change was introduced and there was no control.

One paper was excluded from the update because the baseline hand hygiene data reported had been collected by self-report (Rykkje 2007). Nine papers were excluded because they did not present data relating to hand hygiene or a proxy measure for hand hygiene (Kusachi 2006; Bhutta 2007; McDonald 2007; Suresh 2007; Thu 2007; Barchitta 2008; Capretti 2008; Gopal Rao 2009; Roberts 2009). These papers reported infection rates, but in the absence of hand hygiene data it is impossible to relate the reported changes in infection to increased hand hygiene compliance rather than to other events which either formed part of the intervention or which occurred coincidentally and were not reported by the authors. The ITS study by Huang 2006 is an example of a study where it was impossible to disentangle the effects of other elements of the care bundle approach intended to reduce MRSA bloodstream infections, of which attempts to increase hand hygiene compliance formed only one facet. Another paper was excluded because it reported baseline data with no follow-up (Stone 2007). The authors and funding body were contacted but no further information on the progress of the project could be obtained.

Overall, while the types of studies did differ between the original review and update, the reasons for exclusion were similar in both, primarily relating to insufficiency of control groups or inadequate data points in ITS studies.

Risk of bias in included studies

The Risk of Bias tables summarize the risk of bias in each study.

Allocation

The one RCT (Huang 2002) did not describe allocation method or concealment. The other study designs did not consider allocation concealment.

Blinding

Blinding was done in only one of the four included studies (Gould 1997).

Incomplete outcome data

Huang 2002 had 98% follow-up. The study by Gould 1997 reported similar attrition rates in both groups, but whether the loss in the two arms were comparable was not reported. There was no reporting in the other two studies (Vernaz 2008; Whitby 2008) of whether complete follow-up was obtained.

Selective reporting

None of the four studies reported had published a protocol or described the outcomes chosen in advance of the conduct of the study.

Other potential sources of bias

Huang 2002 used the percent of nurses who performed hand hygiene during the 30 minutes of observation as the outcome measure. This outcome was not clearly described in terms of whether hand hygiene was performed each time it was required or if it was just performed at any time during the observation period. It is possible that actual adherence was overestimated, and uncertain if the overestimation of the adherence would be similar in both groups.

Effects of interventions

Table 1 summarizes the key results from the included studies. In brief, in the study by Huang 2002, four months post-education, hand hygiene compliance was significantly improved ($P < 0.001$) for the nurses in the experimental group compared to the control. In contrast, Gould 1997 found that three months after their education intervention, the number of essential hand hygiene episodes performed was similar in the intervention and control groups.

Table 1. Summary of Results

Study	Measurement Period	Comparisons	Main Effect: Hand hygiene (HH)	Effect: Infection rates	Notes
Huang 2002	Baseline vs. 4 months post-intervention	Education group vs. control group	<p>Percentage of 49 nurses who used appropriate HH <i>before</i> patient contact:</p> <p>Education group:</p> <ul style="list-style-type: none"> - pre : 51% - post 85.7% <p>Control group</p> <ul style="list-style-type: none"> - pre 53.1% - post 53.1% <p>Percent- age of 49 nurses who used appropriate HH <i>after</i> patient contact:</p> <p>Education group:</p> <ul style="list-style-type: none"> - pre : 75.5% - post 91.8% <p>Control group</p> <ul style="list-style-type: none"> - pre 75.5% - post 71.4% 	Not assessed	<p>Significant increase in education group at post test for both before patient contact ($p < .001$) and after patient contact ($P < .05$) compared to control and baseline</p> <p>No confidence intervals reported</p>
Gould 1997	Baseline vs. 3 months post intervention	Education group vs. control group	<p>Percentage of essential hand decontamination:</p> <p>Education group:</p>	Not assessed	No significant difference between education and control groups

Table 1. Summary of Results (Continued)

			- pre : 54.5% - post 58.6% Control group - pre 54.4% - post 64.1%		No confidence intervals reported
Vernaz 2008	Monthly observations: - Baseline: February 2000 to spring 2003 - VigiGerme campaign: spring 2003 to summer 2005 WHO campaign: summer 2005 to September 2006		Monthly use of litres of ABHR: Baseline (2001): 1.303 litres per 100 patient-days increased to 2.016 litres in 2006 with ARIMA model showing effect after both promotions	Significant association found between ABHR use and decreased MRSA but no association found for <i>C. difficile</i> No change in use of antibiotics over time	Significant increases in ABHR use in both periods compared to baseline ($P < .0001$ after VigiGerme and $P = .0013$ after WHO)
Whitby 2008	Monthly observations: 4 or 5 months at baseline	2 years post-intervention: monthly observations	'Geneva' intervention: increased product use by 56% in the infectious diseases unit (IRR= 1.56, 95% CI = 1.29 to 1.89 $P < 0.001$), but not the medical wards (IRR=1.14, 95% CI = 0.93 to 1.39; $p = 0.204$). 'Washington' intervention: 48% increase in product use (IRR=1.48, 95% CI = 1.20 to 1.81 $P < 0.001$) which was sustained over two years. No differences in product use for simple replacements.	Not assessed	Significant increase in one ward for Geneva intervention but not for other ward. Significant increase for Washington intervention

ABHR: alcohol-based hand rub

ARIMA: autoregressive integrated moving average

C. clostridium

CI: confidence interval

HH: hand hygiene

IRR: incidence rate ratio

MRSA: methicillin-resistant *Staphylococcus aureus*

WHO: World Health Organization

Vernaz 2008 reported an increase of product use from 1.3 litres per 100 patient-days in 2001 to 2 litres per 100 patient-days following their multi-modal education campaigns. According to the results of ARIMA modeling, consumption of alcohol-based product reduced the number of new MRSA isolates by 0.03 per 100 patient-days but had no impact on the number of new isolates of *C.difficile*. It is not possible to ascertain how great the effect of implementation of guidelines for the control of MRSA and *C. difficile* would be, compared to the hand hygiene campaigns, on the increases in use of alcohol-based hand rub that were seen.

Whitby 2008 found that removing or changing alcohol-based hand rub with minimal training did not increase product use. The 'Geneva' intervention was partially successful, increasing product use by 56% in the infectious diseases unit (IRR=1.56, 95% CI = 1.29 to 1.89; $P < 0.001$), but not in the medical wards (IRR=1.14, 95% CI = 0.93 to 1.39; $P = 0.204$). The 'Washington' intervention resulted in a 48% increase in product use (IRR=1.48, 95% CI = 1.20 to 1.81; $P < 0.001$) which was sustained over two years.

DISCUSSION

Summary of main results

In summary, only four studies met the criteria for inclusion in this review. Two studies examined education as the intervention (Huang 2002; Gould 1997) while the other two presented complex initiatives. Vernaz 2008 and Whitby 2008 examined similar campaigns, based on Pittet 2000, which evaluated the effects of alcohol-based hand rub, continual reminders, and performance feedback. Whitby 2008 also examined simple substitutions of products with minimal education, as well as a second multifaceted campaign that was similar to the Swiss campaign but with an added component of involving staff in the change process. Vernaz 2008 also examined a second multifaceted campaign where the additional component was application of social marketing theory. Study designs were also different. Huang 2002 used an RCT design, while Gould 1997 used a CBA, and the other two used an ITS design. A variety of outcome measures were used: percent of nurses who performed hand hygiene, percent frequency of hand washes after high risk activities, and product use, expressed as either litres per 100 patient-days or incidence rates of the expected hand hygiene events. Thus, interventions, designs and outcome measures were all different, and so it was not possible to pool results for a meta-analysis.

In terms of effects of the interventions, one of the education campaigns found an increase in hand hygiene (Huang 2002), while the other did not (Gould 1997). The simple substitutions were not associated with an increase in product use (Whitby 2008). The campaigns based on the Swiss model showed an increase in product use in two of the three units where applied, for example, the unit in the study by Vernaz 2008 and one of two units

in Whitby 2008. Product use also increased in the units with the social marketing campaign (Vernaz 2008) and the campaign with staff involvement (Whitby 2008).

Overall completeness and applicability of evidence

Despite the importance of hand hygiene to reduce HAIs and increase in the number of intervention studies since July 2006, the evidence base remains poor. Since the original Cochrane review there is still a dearth of methodologically robust studies to explore the effectiveness of interventions to increase hand hygiene compliance and in some studies the quality of study designs has declined. Uncontrolled before and after studies still form the largest group and although the number of ITSs is increasing, most contain too few data collection points to account for seasonal and secular trends which might affect the data and the auto-correlation among measurements repeatedly taken over time (Ramsay 2003). The three ITS studies in the original search, and 12 of the 14 identified in our most recent searches did not include the minimum pre-intervention and three post-intervention data collection points.

None of the four studies reviewed or the excluded studies considered economic outcomes. The cost of implementing the intervention was mentioned in only one excluded study (Marra 2008). Similarly there was no mention of health service utilization outcomes such as readmission rates, changes in levels of health care, length of patients' stay or the effects of any of the interventions on patients' health.

In the first review we noted the dearth of studies which reported microbiological data. In the update routinely collected surveillance data were reported in at least half of the 84 studies considered, but microbiological sampling of hands to determine whether hand hygiene actually reduced bacterial counts was reported in only three excluded studies (Kusachi 2006; Widmer 2007; Rupp 2008). In spite of the increased use of routinely collected surveillance data, because of insufficient control of confounding factors it was not possible to determine the effects of increased hand hygiene on infection rates.

In addition to the increased tendency to undertake ITSs, other trends were noted. There is a move towards measuring product use in addition to, or instead of, directly observing hand hygiene. This has the potential to improve the quality of studies as it eliminates the Hawthorne effect (Roethlisberger 1939). Along with the ITS design, it also increases feasibility of longer term follow-up, as well as collects data relating to all healthcare workers, not just nurses, which is important as all have the potential to contribute to HAIs. What is not clear in such studies is whether everyone who used the product has had the intervention; if not, the data may underestimate the effect. It is also possible that use by visitors to the wards who do not have direct patient contact could account

for some of the changes in product use.

Post-intervention follow-up was longer in the new studies included in this update than in the original review, but because the study findings were so mixed, we were unable to determine whether the interventions were associated with a sustained increase in hand hygiene compliance. Where data were collected by direct observation, audit methods show some improvement, with greater awareness of the need to report information such as details of auditors' training and quality control which might affect reliability and validity of findings (Gould 2007).

One additional trend of note is the increased use of care bundles for reducing HAIs, with strategies to improve hand hygiene one aspect of these care bundles. Even when hand hygiene data are presented separately it is impossible to disentangle the impact of the different facets.

Quality of the evidence

While the four included studies met the criteria for inclusion for the review, they were not without some risk of bias.

With the outcome measure used by Huang 2002, percent of nurses who performed hand hygiene during the 30 minutes of observation, the researchers may have overestimated the improvement in hand hygiene. Without a more precise measure of hand hygiene, it is not possible to be sure of the changes that occurred in each group and thus accurately assess the effect of education on promoting appropriate hand hygiene. In contrast, the effect of education on hand hygiene may have been underestimated in the study Gould 1997, where the sample size was small and the education program not implemented as planned.

The differences in participant groups, variety of interventions and product use as the outcome measure in the studies by Whitby 2008 and Vernaz 2008 make it difficult to draw conclusions about the effects of those interventions. Furthermore, in the study by Vernaz, it was not possible to evaluate the effect of the concurrent implementation of guidelines for MRSA and *C.difficile* control on hand hygiene.

Superficially, the results of the four studies do seem to indicate that multifaceted campaigns that include social marketing or involvement of staff may be more effective than campaigns without those components, but the latter are more effective than simple product substitutions or education alone. The limited amount and the quality of the evidence, however, limit the ability to draw a firm conclusion about the effectiveness of any of these interventions in promoting hand hygiene. Further evidence is required to be able to draw clear conclusions about which interventions are the most useful.

AUTHORS' CONCLUSIONS

Implications for practice

Although this update has been unable to provide clear evidence of the effect of interventions to promote hand hygiene compliance or reduce HAIs, the findings should not be taken to suggest that attempts to promote hand hygiene compliance or reduce HAIs are not worth undertaking. Much HAI is spread by direct contact and it is logical to suppose that hand hygiene can interrupt the chain of infection, especially when the active ingredient in the hand hygiene agent is applied systematically to all surfaces of hands (Widmer 2008). Hand hygiene at appropriate times is highly desirable on aesthetic grounds alone, forms an important indicator in the quality of care which is important to patients and their families, and should continue to be promoted in all clinical settings.

Implications for research

Soundly designed studies are still required to evaluate the effectiveness of interventions intended to improve hand hygiene compliance and reduce HAIs. Adequately powered cluster randomised trials or well designed ITS studies with at least 12 month follow-up would provide the optimal study design; the latter may be more feasible. There seems to be a trend towards using product use instead of direct observation for outcomes but more research is needed about the validity and reliability of this as a measure of appropriate hand hygiene (Haas 2007). Researchers should also consider potential modifying variables such as nurse/patient ratio or another measure of workload, accessibility of hand hygiene products, and healthcare worker skill mix. Finally the choice of intervention to be studied should be considered in terms of underpinning theoretical frameworks, for example, drawing on knowledge from the behavioural and social sciences, especially social cognitive models (Pittet 2004). The two new studies in this update do indicate that the addition of social marketing or staff input may improve hand hygiene, but the evidence is not strong in terms of drawing conclusions about what aspects of a campaign are effective, since not all units showed improvements.

ACKNOWLEDGEMENTS

We would like to thank Russell Gruen, Martin Eccles, Virginia Roth and Elizabeth Waters for their helpful comments with the first review. We would like to thank Rosa Benato for help with translating the Spanish papers and Professor Alison McFarlane for help translating the French papers for the update. We would also like to acknowledge Michelle Fiander for her help with the search strategy and Alain Mayhew, Rachel Bennett, Laura Nichol and Jeremy Grimshaw for their helpful comments and assistance in preparing this review for publication.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Gould 1997

Methods	Design: CBA Duration: 3 months baseline and 3 months post-intervention	
Participants	UK Nurses on 4 general surgical wards	
Interventions	Single teaching session: hand hygiene, universal precautions	
Outcomes	% frequency of hand washes after high risk activities	
Notes	Intervention not successful at 3 months Also evaluated knowledge of infection control, observed glove use, and observed handling of used needles	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	CBA study, not done
Allocation concealment (selection bias)	High risk	CBA study, not done
Blinding (performance bias and detection bias) All outcomes	Low risk	Unclear in paper, but confirmed through personal communication with author
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data was only collected from 31 of 50 nurses; attrition or lost to follow-up rates were similar in both groups but not specified if characteristics of dropouts were similar
Selective reporting (reporting bias)	Unclear risk	No published protocol, unable to determine
Other bias	Low risk	No other biases identified
Baseline outcomes	Low risk	Data reported as similar between 2 groups
Baseline characteristics	Unclear risk	Characteristics mentioned as similar in text but no data were presented

Gould 1997 (Continued)

Protection from contamination	Unclear risk	Control group likely did not get intervention but intervention group members did not receive all intended education
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Huang 2002

Methods	Design: RCT Duration: 4 months post-intervention
Participants	People's Republic of China Nurses throughout a hospital
Interventions	Education, mainly universal precautions
Outcomes	% of nurses washing hands before and after patient contact
Notes	Intervention successful after 4 months Also evaluated knowledge scores, prevalence of Hepatitis B immunization, self reported behaviours related to bloodborne pathogens and universal precautions, self reported needlestick and sharps injury, and observed behaviours related to handling used needles.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not specified
Allocation concealment (selection bias)	Unclear risk	Not specified
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	98% follow-up achieved
Selective reporting (reporting bias)	Unclear risk	No published protocol
Other bias	Unclear risk	The outcome measure, percent of nurses who performed hand hygiene during the 30 minutes of observation, was not clearly described in terms of whether hand hygiene was performed each time it was required or if it was just performed at any time during the observation period. It is possible that actual adherence was overestimated, although

Huang 2002 (Continued)

		this would apply equally to both groups and not affect the difference between the groups.
Baseline outcomes	Low risk	Similar scores for both groups
Baseline characteristics	Low risk	Similar scores for both groups
Protection from contamination	Unclear risk	No description of protection against contamination

Vernaz 2008

Methods	Design: ITS Duration: February 2000 to September 2006
Participants	Switzerland Healthcare workers throughout hospital
Interventions	Social marketing campaign (VigiGerme®) in 2003 and <i>Clean Care is Safer Care</i> campaign in 2005
Outcomes	Volume of hand hygiene products (litres per 100 patient-days)
Notes	Both interventions successful for short-term increase in hand hygiene Also measured new MRSA isolates per 100 patient-days, new <i>C. difficile</i> isolates per 100 patient-days, defined daily dose of antibiotics per 100 patient-days

Risk of bias

Bias	Authors' judgement	Support for judgement
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Number of subjects not specified
Selective reporting (reporting bias)	Unclear risk	No protocol published, unable to determine
Other bias	Low risk	No other biases identified
Intervention independent	High risk	MRSA/ <i>C. difficile</i> control policies and Contact Precautions were implemented at the same time
Shape of effect pre-specified	Low risk	Point of analysis same as point of intervention
Intervention had no effect on data collection	Low risk	Data collection not associated with intervention

Vernaz 2008 (Continued)

Protection from contamination	High risk	Subjects were aware of intervention
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Whitby 2008

Methods	Design: ITS Duration: Each intervention took place over a 2 year period
Participants	Australia All healthcare workers in multiple units
Interventions	3 separate interventions: 1) Simple substitutions: ABHR for soap, and one type of ABHR for another 2) Geneva campaign 3) Washington campaign
Outcomes	Product use (hand hygiene events per occupied-bed days)
Notes	Intervention successful for Geneva and Washington campaigns

Risk of bias

Bias	Authors' judgement	Support for judgement
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Number of subjects not specified
Selective reporting (reporting bias)	Unclear risk	No evidence of protocol published, unable to determine
Other bias	Unclear risk	Unclear how group differences (e.g. characteristics of patients) may have impacted outcome for wards receiving Geneva intervention
Intervention independent	Low risk	No other changes identified
Shape of effect pre-specified	Low risk	Point of analysis same as point of intervention
Intervention had no effect on data collection	Low risk	Data collection not associated with intervention
Protection from contamination	High risk	Subjects aware of intervention

ABHR: alcohol-based hand rub
C. clostridium

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Apisarnthanarak 2008	Uncontrolled before and after design
Assanasen 2008	Interrupted time series study, inadequate data collection points
Avila-Aguero 1998	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Baker 1998	Uncontrolled before and after study design
Barchitta 2008	No hand hygiene outcome data presented
Bellis 2006	Interrupted time series study, inadequate data collection points
Berg 1995	Uncontrolled before and after study design
Berhe 2006	Uncontrolled before and after design
Bhojani 2008	Uncontrolled before and after design
Bhutta 2007	No hand hygiene outcome data presented
Bischoff 2000	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Bittner 2002	Controlled before and after study design with one nonequivalent control group.
Brown 2003	Uncontrolled before and after study design
Cantrell 2009	Uncontrolled before and after design
Capretti 2008	No hand hygiene outcome data presented
Chan 2007	Uncontrolled before and after design, no baseline data
Chimango 2009	Uncontrolled before and after design
Christiaens 2009	Interrupted time series design with less than three data entry points after the intervention.
Coghill 2009	Uncontrolled before and after design
Coignard 1998	Uncontrolled before and after study design

(Continued)

Colombo 2002	Controlled before and after study design with one nonequivalent control group.
Conly 1989	Interrupted time series design with less than three data entry points before/after each intervention.
Creedon 2005	Uncontrolled before and after study design
Creedon 2006	Uncontrolled before and after design
Cromer 2008	Uncontrolled before and after design
das Neves 2006	Uncontrolled before and after design
Diekema 1995	Uncontrolled before and after study design
Diersson-Sotos 2008	Uncontrolled before and after design
Donowitz 1986	Interrupted time series design with less than three data entry points before/after each intervention.
Dorsey 1996	Uncontrolled before and after study design
Dubbert 1990	Uncontrolled before and after study design
Duerink 2006	Controlled before and after study, inadequate control, no baseline
Duggan 2008	Uncontrolled before and after design, no baseline data
Earl 2001	Uncontrolled before and after study design
Ebnother 2008	Uncontrolled before and after design
Eckmanns 2006	Uncontrolled before and after design
Eldridge 2006	Interrupted time series study, inadequate data collection points
Elola-Vicente 2008	Hand hygiene was assessed during simulation and in an artificial setting not involving real patients
Giannitsioti 2009	Controlled clinical trial, inadequate control
Golan 2006	Crossover trial with only one intervention group and one control group
Gopal Rao 2009	No hand hygiene outcome data presented
Graham 1990	Uncontrolled before and after study design
Grayson 2008	Interrupted time series study, inadequate data collection points

(Continued)

Haas 2008	Uncontrolled before and after design
Harbarth 2002	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Harrington 2007	Uncontrolled before and after design
Hon 2008	Hand hygiene was assessed in an artificial setting not involving real patients
Howard 2009	Uncontrolled before and after design, no baseline data
Huang 2006	Interrupted time series study, inadequate data collection points
Huang 2008	Interrupted time series study, inadequate data collection points
Hughes 1986	Uncontrolled before and after study design
Hugonnet 2002	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Hussein 2007	Uncontrolled before and after study
Khatib 1999	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Kohli 2009	Controlled clinical trial, inadequate control
Kusachi 2006	No hand hygiene outcome data presented
Lam 2004	Uncontrolled before and after study design
Larson 1991	Controlled before and after study design with one nonequivalent control group.
Larson 1997	Controlled before and after study design with one nonequivalent control group.
Larson 2000	Controlled before and after study design with one nonequivalent control group.
Larson 2007	No clear intervention
Lausten 2009a	Uncontrolled before and after design
Lausten 2009b	Uncontrolled before and after design
Lee 2009	Uncontrolled before and after design
Macdonald 2006	Hand hygiene was assessed during simulation

(Continued)

Madani 2006	Interrupted time series study, inadequate data collection points
Marena 2002	No control group for intervention of interest
Marra 2008	Controlled clinical trial, no baseline data, inadequate control
Maury 2000	Limited or no baseline data
Mayer 1986	Controlled before and after study design with one nonequivalent control group.
McDonald 2007	No hand hygiene outcome data presented
McGuckin 1999	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
McGuckin 2004	Uncontrolled before and after study design
McGuckin 2006	Uncontrolled before and after design
McLaws 2009	Interrupted time series study, inadequate data collection points
Milward 2007	Hand hygiene was assessed in an artificial setting not involving real patients
Miyachi 2007	Interrupted time series study, inadequate data collection points
Moongtui 1999	Data pertaining to hand hygiene were not presented separately from data related to universal precautions
Moore 1980	No data were presented
Muto 2000	Uncontrolled before and after study design
Muto 2007	Uncontrolled before and after design, no baseline data
Nouira 2008	Uncontrolled before and after design
Panhotra 2004	Limited or no baseline data
Pessoa-Siilva 2007	Uncontrolled before and after design
Picheansathian 2008	Interrupted time series study, inadequate data collection points
Pittet 2000	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Prieto 2005	Uncontrolled before and after study design
Raju 1991	Interrupted time series design with less than three data entry points before/after each intervention.

(Continued)

Randle 2006	Uncontrolled before and after design, no baseline data
Raskind 2009	Uncontrolled before and after design
Roberts 2009	No hand hygiene outcome data presented
Rose 2009	Uncontrolled before and after design
Rosenthal 2003	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Rosenthal 2008	Uncontrolled before after design; amalgamated data from 18 countries, no control groups
Rummukainen 2009	Uncontrolled before and after design
Rupp 2008	Crossover trial with only one intervention group and one control group
Rykkje 2007	Hand hygiene data collected by self-report
Sacar 2006	Uncontrolled before and after design
Salemi 2002	Uncontrolled before and after study design
Sanchez-Paya 2007	Uncontrolled before and after design
Santana 2007	Uncontrolled before and after design
Schneider 2009	Uncontrolled before and after design
Shaw 2003	Uncontrolled before and after study design
Siegel 2007	Uncontrolled before and after design
Simmons 1990	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Snow 2006	No clear intervention
Souweine 2009	Uncontrolled before and after design
Stone 2007	Reported only baseline data, no follow-up data
Suchitra 2007	Uncontrolled before and after design
Suresh 2007	No hand hygiene outcome data presented

(Continued)

Swoboda 2004	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Swoboda 2007	Uncontrolled before and after study design, reanalysis of previous data
Tenias 2009	Uncontrolled before and after design
Thomas 2005	Limited or no baseline data
Thomas 2009	Uncontrolled before and after design
Thu 2007	No hand hygiene outcome data presented
Tibbals 1996	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Traore 2007	Uncontrolled before and after design
Trick 2007	Controlled before and after study, inadequate control
Van de Mortel 1995	Uncontrolled before and after study design
Van de Mortel 2000	Uncontrolled before and after study design
Van de Mortel 2006	Interrupted time series study, inadequate data collection points
Venkatesh 2008	Uncontrolled before and after design
Wharton 2006	Uncontrolled before and after design
Whitby 2004	Uncontrolled before and after study design with sequential addition of new intervention(s) but limited data collection after each addition.
Widmer 2007	Uncontrolled before and after design
Won 2004	Uncontrolled before and after study design
Xue 2008	Uncontrolled before and after design
Zingg 2009	Uncontrolled before and after design

DATA AND ANALYSES

This review has no analyses.

APPENDICES

Appendix I. Additional Search Strategies

Original Search Strategy

We searched MEDLINE from 1980 to July 2006 using the following search strategy:

1. HAND HYGIENE or HAND WASHING
 2. ((#1 and EDUCATION) or KNOWLEDGE)
 3. (#1 and HEALTH PROMOTION)
 4. (#1 and AUDIT)
 5. (#1 and COMPLIANCE)
 6. (#1 and PRODUCT AVAILABILITY)
- (#1 and CROSS INFECTION or NOSOCOMIAL INFECTION) or HOSPITAL ACQUIRED INFECTION or HEALTH-CARE ASSOCIATED INFECTION)

Search strategy for other databases

Evidence-Based Medicine Reviews

EBM Reviews is a collection of four databases related to evidence-based medicine:

ACP Journal Club

Cochrane Central Register of Controlled Trials

Cochrane Database of Systematic Reviews

Database of Abstracts of Views of Effects (DARE)

Date 15/10/2009

Search for: from 13 [limit 12 to yr="2005 Current" [Limit not valid in DARE; records were retained]] keep 1-96

Results: 1-96

Database: All EBM Reviews

Search Strategy:

- 1 handwashing.sh. (178)
- 2 handwash\$.tx. (21)
- 3 hand wash\$.tx. (38)
- 4 hand disinfection.tx. (3)
- 5 hand hygiene.tx. (20)
- 6 surgical scrub\$.tx. (7)
- 7 hand decontamination.mp. [mp=ti, to, ab, tx, kw, ct, sh, hw] (4)
- 8 hand cleansing.mp. [mp=ti, to, ab, tx, kw, ct, sh, hw] (11)
- 9 hand cleaning.mp. [mp=ti, to, ab, tx, kw, ct, sh, hw] (2)
- 10 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 (249)
- 11 from 10 keep 1-249 (249)
- 12 10 (249)
- 13 limit 12 to yr="2005 Current" [Limit not valid in DARE; records were retained] (96)
- 14 from 13 keep 1-96 (96)
- 15 from 14 keep 1-96 (96)

British Nursing Index BNI

Search for: limit 12 to last 5 years (June 2005 to May 2010)

Results: 1-89

Database: EBM Reviews Cochrane Database of Systematic Reviews <2005 to May 2010>

Search Strategy:

- 1 handwash\$.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (21)
- 2 hand wash\$.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (27)
- 3 hand antiseptis.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (5)
- 4 hand disinfection.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (6)
- 5 hand hygiene.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (19)
- 6 hand decontamination.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (1)
- 7 hand cleansing.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (0)
- 8 hand cleaning.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (0)
- 9 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 (48)
- 10 hand.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (2288)
- 11 sterilization.vo,yr,ti,ip,hw,an,ab,sh,au,jn,af,up,is,jx. (49)
- 12 9 or 11 (93)
- 13 limit 12 to last 5 years (89)
- 14 from 13 keep 1-89 (89)

Additional Search Strategy

1. Handwashing/ [ML]
2. (handwash\$ or hand hygiene or handrub\$ or hand rub\$).ti,ab.
3. (hand? adj2 (clean\$ or decontaminat\$ or disinfect\$ or hygiene or hygienic\$ or saniti\$ or sterili\$ or wash\$)).ti,ab.
4. (hand\$ adj3 (alcohol\$ or propanol\$ or ethanol\$)).ti,ab.
5. (hand\$ adj scrub\$).ti,ab.
6. (antiseptis/ or sterilization/ or disinfection/) and Hand/ [ML]
7. (hand? adj2 (aseps\$ or aseptic\$ or antisept\$)).ti,ab.
8. ((surgery or surgical) adj2 (scrub\$ or rub\$)).ti,ab.
9. or/1-8 [Hand Hygiene]
10. Cross Infection/pc [Prevention & Control]
11. Infectious Disease Transmission, Professional-to-Patient/
12. (health care associated infection? or healthcare associated infection?).ti,ab.
13. (nosocomial adj2 (infection? or disease?)).ti,ab.
14. ((hospital or icu or intensive care) adj2 acquired adj2 infection?).ti,ab.
15. or/10-14 [HAI/Nosocomial infection]
16. Infection Control/ 17. (infection and (control\$ or prevent\$)).ti.
19. Universal Precautions/ or universal precautions.ti,ab.
20. or/16-17,19 [Infection Control]
22. 15 and 20 [HAI & Infect Control]
24. 9 or 22 [HH or HAI/Nosocomial Infect Control]

WHAT'S NEW

Last assessed as up-to-date: 2 August 2010.

Date	Event	Description
7 July 2011	Amended	Minor edits

HISTORY

Protocol first published: Issue 4, 2004

Review first published: Issue 2, 2007

Date	Event	Description
3 August 2010	New citation required but conclusions have not changed	Two new studies added, no change in conclusions. Review now includes risk of bias table for all included studies and new searches up to November 2009. Review author order has been revised to reflect contribution for this update.
3 August 2010	New search has been performed	New search, screening, two new studies included
24 June 2008	Amended	Converted to new review format.
7 February 2007	New citation required and conclusions have changed	Substantive amendment

CONTRIBUTIONS OF AUTHORS

JC and ND were responsible for the initial and updated searches, respectively. Papers were reviewed by DJG, DM and ND for both reviews, and JC also reviewed papers in the initial review. ND or DM acted as arbitrator in cases of disagreement. DJG and DM compiled the final report.

DECLARATIONS OF INTEREST

DJG co-authored one of the studies included in this review.

SOURCES OF SUPPORT

Internal sources

- City Hospital, London, UK.
- Memorial University School of Nursing, St John's, Canada.

External sources

- Department of Health Cochrane Review Incentive Scheme 2005 and 2010, UK.

INDEX TERMS

Medical Subject Headings (MeSH)

*Health Personnel; Clostridium Infections [prevention & control]; Clostridium difficile; Cross Infection [*prevention & control]; Handwashing [*standards]; Infectious Disease Transmission, Professional-to-Patient [*prevention & control]; Methicillin-Resistant Staphylococcus aureus; Staphylococcal Infections [prevention & control]

MeSH check words

Humans